A Preliminary Note on Branched α-Ray Tracks.

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(Communicated by Sir E. Rutherford, F.R.S. Received June 4, 1921.)

According to Prof. Sir E. Rutherford,* if about one hundred thousand α-rays from radium C pass through the air, on the average there will be one close nuclear collision, which produces a swiftly moving atom. Thus, if we take a great number of photographs of α-ray tracks compatible with the above order of magnitude, we might expect to find some evidence to indicate the disruption of atoms by the α-particles. The present note is to describe some preliminary trials in this direction.

The reciprocating expansion apparatus of the preceding article is very convenient for taking a large number of photographs within a reasonable time. Direct eye-observation confirmed the existence of some branched tracks which differed greatly in configuration from spurred tracks like the one photographed by Mr. C. T. R. Wilson.† Arrangements were then made to devise a suitable method of photographing such tracks and to show their orientation in space.

The use of cinematographic film seemed to be imperative and the camera was designed accordingly. It is run by the same shaft as the piston of the expansion chamber, so that the exposures are made automatically and synchronously with the apparatus. An ordinary photographic shutter is used and photographs are taken once in each expansion when the piston is at its lowest position, and therefore the air in the chamber is practically motionless. The time of exposure can be extended as long as one-fiftieth of a second without impairing the definition. The source of light employed is a carbon arc in combination with a condenser and a water-cooling device. The parallel beam of light, after passing through the chamber, is reflected back again by means of a plane mirror fixed on the other side of the chamber. The lens used is an Aldis F/3.

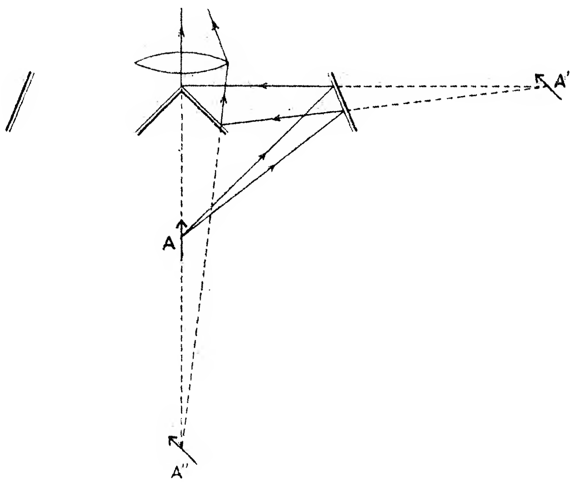
The special feature of this camera lies in the use of a mirror system which projects simultaneously two images of the object, viewed from mutually perpendicular directions, through the same objective lens. The principle is sketched in the figure. It is nothing but a variety of an ordinary range-finder.

Four mirrors with surface-silvering (indicated by a fine line in the figure) are used, two of which are fixed immediately in front of the lens, each

* 'Phil. Mag.,' vol. 37, June, 1919; "Bakerian Lecture," 'Roy. Soc. Proc.,' A, vol. 97, 1920).

† 'Roy. Soc. Proc.,' A, vol. 87 (1912).

making 45° with the vertical, and the other two at equal distances from the axis of the lens and at about the same level as the first pair, but inclined

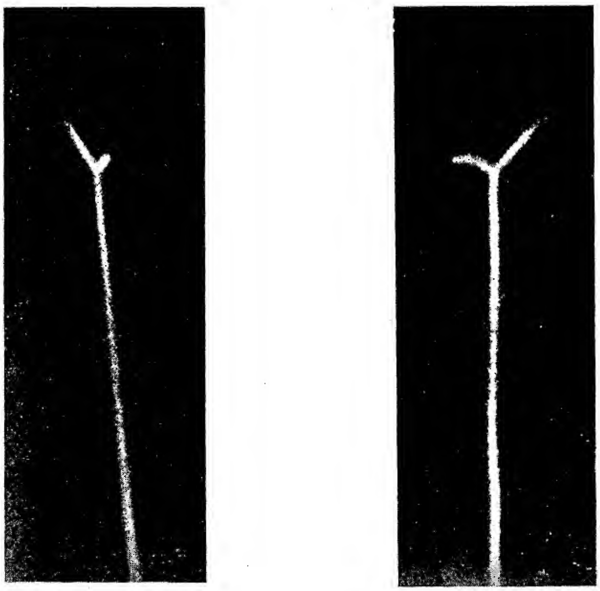


22·5° with the vertical. Both the position and inclination of the outer two should be adjustable, and the distance from the axis is so chosen that the virtual image of an object placed in the line of the axis reflected twice by each pair of mirrors (A, A′, and A″ represent the object, the first, and the second virtual images respectively) comes directly below the object. As can be easily seen from the construction, the pair of mirrors on the right of the axis serve to replace the object with a virtual image tilted by 45° to the left and placed farther away from the lens than the object. The other pair on the left do the same, only with the reversed sense of tilting. Thus, what is seen on the screen is a superposition of two mutually perpendicular views of the same object. In the case of the tracks produced in the expansion apparatus, the object is composed of bright lines on a dark ground instead of a continuous bright surface, and the superposition does not impair the definition of the image. It is always possible to choose an imaginary horizontal line in the middle of the chamber parallel to the mirrors as an axis around which the object space is rotated. When a negative is obtained, a line in the position of this axis will appear as a single line and all in other positions and directions as double lines in general, from the separation and other geometrical data of which the true shape of the object can be deduced. It seems also to be possible to construct a uniformly magnified model of the object in three dimensions directly from the negative, using a similar mirror system as a projecting apparatus. In this case the projected image is the intersection of shadows in space. But, so far, not much actual experiment has been done in this connection.

When many tracks are to be photographed at each expansion, it is better to separate the two images of the object space from each other, so that they occupy different areas on the negative side by side, for then the complication due to overlapping can be avoided. In this case the angle of the outer mirrors with the vertical should be slightly different from 22·5°, and the two companion photographs bear approximately the relation of a plan and a side-view to each other. In either case, the final adjustment of the outer mirrors can be done by putting a cube with white surfaces in place of the expansion chamber.

If the conditions are favourable, one ought to be able to get a thousand or more exposures in an hour. But so far, owing to various difficulties, only about 200 feet of film has been exposed, and the writer cannot at present do more than produce a typical sample of branched tracks photographed with the apparatus.

In the accompanying figure, the two photographs are two mutually perpendicular views of the same track of an α-ray emitted by polonium, taken by the second of the two methods of mirror arrangement described above. In this reproduction the end parts of the track were enlarged 13·2 times from the negative, cut out, and brought together to a convenient distance. The image on the negative itself was 0·42 times the size of the object, so that the true magnification of the reproduction is about 5·5. In this particular exposure



Photograph of a branched α-ray track viewed from two positions at right angles to each other. Actual magnification 5·5.

there was only one track recorded, but usually there are several and it is an easy matter to decide which track in the two images correspond. The slight departure from a straight path noticeable in one of the accompanying photographs is in this case more likely due to an optical error caused by a slight local heterogeneity in the thickness of the gelatine film than to a movement of the air, although it is true that a distortion of this magnitude can arise from the latter cause. The marked smooth curvature in one of the branches cannot be attributed to these disturbances, and is typical of numerous α-ray tracks which finish their range in that way.

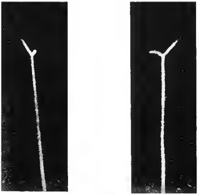
In the course of these preliminary experiments, about 3,000 α-ray tracks were photographed and eleven tracks were observed branching like the one shown in the plate, the number of spurred tracks being about thirty-five. Although a far greater number of photographs are required to estimate with accuracy the percentage of such branched tracks, it seems probable that it is not very far from one in a few hundreds.

One of the striking features about the branches is that their shapes and sizes are very similar. The frequent occurrence of such marked branching is very surprising.

With the spurred tracks, the abrupt bending takes place at different distances from the source and the deflection after collision seems to have a wide range, while with the branched tracks the branching takes place near the end of the path and the angle subtended by the branches does not seem to differ much, at any rate, in the small number of cases which have been observed.

No such high percentage of production of swiftly-moving atoms has been observed by the scintillation method, either for recoil or disruption of atoms by collision. This is not contradictory because the expansion method detects moving atoms within the range of the α-rays, which the other method fails to do. At any rate the percentage alone cannot be any clue to the nature of the branching. On the other hand, although a calculation from the geometrical data based upon ordinary laws of dynamics and of the range of particles indicates that the atoms after branching possess nearly equal masses, none of these laws can be relied upon with certainty if disintegration of an atom occurs. It is difficult to speculate with confidence at present about the nature of these rays, and the conclusion must be suspended until sufficient data accumulate.

In conclusion the writer wishes to express his sincere gratitude to Prof. Sir E. Rutherford, who suggested the problem, for his kind encouragement and guidance.



Photograph of a branched α-ray track viewed from two positions at right angles to each other. Actual magnification 5·5.